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ORIGINAL ARTICLE

The Dark Geocultural Heritage of Volcanoes: Combining Cultural and Geoheritage Perspectives for Mutual Benefit

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Abstract

It is now widely accepted that vulnerability to natural hazards is dependent on cultural and historical factors. Similarly, geoheritage cannot be readily disentangled from cultural values and cultural heritage. The assignment of value to a given geosite is conducted in the present, and many, if not most geosites, are also sites of culture-historical significance. Conversely, most tangible cultural heritage also contains elements of geoheritage. To merge aspects of geoheritage and of cultural heritage, the notion of geocultural heritage has been proposed; we build on this and argue that the viewpoints of geoheritage and of cultural heritage—here especially of dark heritage—can be brought further together for mutual benefit. We begin by demonstrating through a bibliometric analysis that the two fields are at present unduly disjointed. We then illustrate how geoheritage and dark cultural heritage can be brought together through four case studies of past volcanism and their complex human entanglements. In conclusion, we encourage heritage workers to be more fully interdisciplinary, to read more widely outside their own fields and to disseminate their research more broadly for mutual benefits of geoheritage valorisation, conservation and risk reduction.

Keywords Geoheritage · Cultural heritage · Dark heritage · Geotourism · Dark tourism · Social volcanology

Introduction

Geoheritage focuses on the appreciation and protection of the diversity of minerals, rocks and fossils, as well as geomorphological features that illustrate the effects of present and past climate and environmental change (McBriar 1995; Gray 2013). The attribution of value to these geological features is based on the argument that they both constitute resources for science, education and tourism and that they provide a sense of place tied to historical, cultural, aesthetic and religious values (Brocx 2007; Brocx and Semeniuk 2007). The fault tectonic area of the Chaîne des Puys in France is a recognised UNESCO World Heritage Site, and the Kant's Volcano Mine in the Czech Republic is a geological heritage site (Rapprich et al. 2018). Indeed, the history of geological discovery is strongly associated with the ideas of the European 'Enlightenment'—particularly where they connect with geological (vs biblical) ideas of time. In this regard, geology has played a vital role in history and the history of science and ideas. For instance, many Italian 'geotourism' sites have a legacy as part of the Victorian-age 'Grand Tour' and those in Britain with key geological 'discoveries'. Related concepts such as geoconservation and geotourism extend the scope to the preservation of specific landforms (Wyatt and Moss 1990; Blandin 1992; Gibson et al. 1994; Withers and Horwitz 1996) and the enhancement and use of a given geosite in touristic marketing (Stueve et al. 2002; Hose 2012; Ólafsdóttir and Tverijonaite 2018). Importantly, geotourism also aims to raise awareness of the importance of geoheritage—officially recognised or not—and the dissemination of earth science knowledge (Dávid 2004). A geotourist, it is argued, travels to gain increased awareness and knowledge of a given geosite or landform, learning about their natural characteristics and relations to human history, commerce, arts or crafts (Stueve et al. 2002). In this context, even local tourists gain and can be educated and trained in becoming resilient.

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What should be evident from this brief sketch of geoheritage and related disciplinary fields is that they cannot readily be disconnected from cultural heritage because (a) the framing and valorisation of a given geosite is conducted within a specific contemporary cultural setting and (b) the bulk of all geosites recognised by UNESCO directly relate also to aspects of *cultural heritage*—key publications such as the journal *Geoheritage* illustrate as much. In this paper, begin by showing that despite this substantive overlap between geoheritage and cultural heritage, the two fields operate in large separate spheres of theory, method and knowledge production. We then attempt to build stronger bridges between the fields of geoheritage and cultural heritage. We see this as a pressing matter not just because both areas stand to make significant intellectual and practical gains from greater integration, but because thinking geological and cultural heritage together—we use the previously coined short-hand 'geocultural heritage' (Reynard and Giusti 2018)—connects particularly well with research focusing on natural hazards and risk reduction, not least in the context of the Anthropocene debate (cf. Dominey-Howes 2018). It has long been pointed out that the impact of natural hazards is not in any way straightforward or entirely natural, but emerge in the interaction of a given hazard with at-risk communities (O'Keefe et al. 1976) or vice versa that it is the community that interacts with the hazard. It is now widely accepted that vulnerability emerges within the context of a community's history (García-Acosta 2002; Bankoff 2004), and that judgements of risk are largely culturally contingent. Hence, asking the question of what an understanding of culture can offer to disaster risk reduction, as well as ensuring that any risk-reduction measures are culturally sensitive (Mercer et al. 2012), arguably requires novel ways of framing and communicating knowledge. By this token, geoheritage can provide a useful link between culture and disaster risk reduction research and interventions.

As an exemplary, our focus here is on volcanism and its coupled geological and cultural heritage (Németh et al. 2017). Approaches that tackle contemporary volcanism and its impact on human communities in culturally embedded ways have been termed 'social volcanology' (Donovan 2010), signalling the interdisciplinary nature of this endeavour. Past volcanism has also repeatedly affected human communities, and the historical and archaeological remains of these interactions are the basis for a 'palaeo-social volcanology' (Riede 2015, 2019). In the sense that these approaches draw on intangible or tangible *cultural heritage*, they cross the disciplinary boundaries between the humanities and social sciences on the one hand and the geosciences on the other in communicating risk, education and debate (Kelman and Dodds 2009; Parkash 2012; De Lucia 2014; Neuberg 2014; Riede et al. 2016; Migoń and Pijet-Migoń 2019).

Volcanoes have provided human societies with a great number of benefits in terms of ready building materials, geothermal energy (Arnórsson et al. 2015; Dehn and McNutt 2015), through soil improvement and water resources (Ugolini and Zasoski 1979; James et al. 2000; Arnórsson et al. 2015; Dehn and McNutt 2015; Delmelle et al. 2015). Yet, volcanoes are also firmly associated with the awesome spectacles of their eruptions and the usually detrimental impacts these have on human communities. The cliché of the destructive volcano is particularly strong in the *popular* imagination (Pomeroy 2008; Kozák and Cermák 2010; Pyle 2017). The study of such calamities and their tangible and intangible legacies has been termed 'dark heritage', and its use in tourism 'dark tourism' (Hooper and Lennon 2017). While dark heritage and dark tourism focus on those aspects of history which are problematic, unwanted or unsavoury—classic examples of such sites are political prisons such as Alcatraz, Robben Island (Strange and Kempa 2003) or Long Kesh (McAtackney 2013), concentration camps and other war sites (Thomas et al. 2016) or gruesome murders (Foley and Lennon 1996)—they inadvertently exert a substantial pull on visitors (Kulcsar and Simon 2015). Cultural heritage practitioners have long since demonstrated that natural and cultural heritage are inseparable (e.g. Lowenthal 2005), and that the valorisation of any given heritage feature is dynamic and, importantly, often contested. In this context, geoheritage and dark heritage can also be contested.

Knowing of the significant entanglements of natural/geological and cultural heritage, we here use the term geocultural heritage, which has recently been employed in the context of sites that show a particularly strong association or overlap between geological and cultural values (Reynard and Giusti 2018). Trends are underway that bring the fields of geoheritage and cultural heritage together (Coratza et al. 2018), but we argue here that the viewpoints of geoheritage and of cultural heritage—especially of dark heritage—can be brought further together for mutual benefit. Initial attempts aligning these perspectives have emerged in the literature (Erfurt-Cooper et al. 2015), but we demonstrate through a bibliometric analysis that the two fields remain somewhat disjointed. We illustrate how geoheritage and dark cultural heritage can be brought together through four case studies of past volcanism and their complex human entanglements. In conclusion, we encourage heritage workers—both those with disciplinary roots in the geosciences and in the humanities and social sciences—to be more fully interdisciplinary, to read more widely outside their own fields and to disseminate their research more broadly between one another for mutual benefits of preservation, risk reduction and valorisation.

Materials and Methods

In order to assess the current relations between the disciplinary fields of geoheritage and its relatives geoconservation,

geotourism, geoethics and cultural heritage and also its relatives, dark tourism and dark heritage respectively, we have systematically collected key texts and examined their citation relations as a way of understanding whether and to what degree they overlap and interact. While such citation analyses do not necessarily reflect on-the-ground practice, they are likely to serve as a strong proxy for the intellectual backgrounds and perspectives of researchers and practitioners alike (Kuhn 1970; Hull 1988). We subject these texts to a bibliometric citation analysis and visualise the results using network algorithms. In this way, we track patterns of knowledge production, use and the development of these disciplines in an evidence-based fashion (Hull 1988; Hoffmann and Doucette 2012). Previously, citation analysis has been used as a method of assessing research impact of individual publications (Nicolaisen 2007; Sarli et al. 2010), for gauging the extent of a given publication's influence on the literature, for tracking the advancement of knowledge with the inherent assumption that significant publications will demonstrate a high citation count (Wade 1975; Lawani 1977; Kostoff 1998), to detect scientific collaboration and to map knowledge transfer across domains (Ding et al. 2014).

Citation analysis is an integral component of journal ranking criteria and is best known as a tool to assess the impact of individual researchers and their institutions (Nightingale and Marshall 2013). It has been shown that higher citation rates are due to articles (1) being written in English, (2) addressing generalist areas rather than specific disciplines, (3) providing reviews rather than original research, (4) representing cutting-edge research, (5) being longer rather than shorter, (6) addressing established rather than emerging disciplines, (7) appearing in ISI-indexed journals (Seglen 1997), (8) pertaining to methodology, and lastly (9) by being jointly authored by international teams (Whitehouse 2001). To measure an individual researcher's impact the h-index is used. This index calculates the highest number of articles published by a given author that have the same number of citations or above (Nightingale and Marshall 2013). An h-index of three, for instance, shows that the author has published three articles with a minimum of three citations each. This arguably enables citation performance and productivity to be compared while reducing the influence of few but highly cited articles (Nightingale and Marshall 2013). While we do not endorse these tools for assessing individual performance—there are many forms and of and pathways to excellence—they are useful for broad comparisons of large data sets to reveal patterns of interaction between different scientific fields, their associated publication outlets and their key actors.

To investigate citations in the seven disciplinary fields in focus here, we initially employed the *Publish or Perish* software (Harzing 2007). The program was developed to mine academic citations from a variety of online databases on the basis of the parameters chosen by the analyst and to then provide the following metrics:

- Total number of papers and total number of citations
- Average citations per paper, citations per author, papers per author and citations per year
- Number of authors per paper
- h-index
- g-index
- Contemporary h-index

The g-index aims to improve on the h-index by giving more weight to highly cited articles (Egghe 2006), while the contemporary h-index aims to improve the original h-index by giving weight to more recent articles, thus rewarding academics who maintain a steady level of activity (Sidiropoulos et al. 2006). Note that due to the limitations inherent in the program, publications not written in English were excluded. Secondly, publications with no citations were also excluded—these are unlikely to have had a lasting impact on the disciplines in focus here.

Originally, citation data were harvested from three separate sources—Google Scholar©, Microsoft Academic© and CrossRef©—but results were identical; subsequently, only Google Scholar© was used. Data in the following categories were recorded:

- A general search for all published material within the seven disciplinary fields
- The total years of active publishing in each disciplinary field
- The ten most highly cited papers in each disciplinary field
- The ten most prolific authors based on the number of publications
- The ten most common journal destinations where research in the seven disciplinary fields has been published
- Forward citation journal destinations for the ten most highly cited papers and lastly
- Author overlap between disciplinary fields

Once tabulated, patterns in these data are visualised using network methods and Venn diagrams. Networks are efficient and elegant means of visualising relations among the nodes—here individual papers, journals and disciplinary fields—and are regularly used to examine the historical developments of scientific research fields (Fanelli and Glänzel 2013; Chappin and Ligtvoet 2014; Radev et al. 2015). Several software solutions are available (for instance, http://www.vosviewer.com/ or Sci2 (see Lewis and Alpi 2017)). Here, we employ the open-source *gephi* suite (https://gephi.org/ (see Bastian et al. 2009)). Venn or Euler diagrams are well-known, simple and intuitive yet not trivial visualisations of logical set relations. Each Eulerian circle represents an independent data class and

the degree of intersection between circles is scaled to their relation with one another (Venn 1880; Ruskey and Weston 2005). In particular, Venn diagrams efficiently capture the degree of overlap between classes of data. In order to generate Venn diagrams, we here use *VennMaster* (http://www.informatik.uni-ulm.de/ni/mitarbeiter/HKestler/vennm/doc.html (see Kestler et al. 2005)).

Results

Table 1 summarises the bibliometric findings of this citation analysis. Several striking differences emerge between the disciplinary fields investigated. First, research within the domain of cultural heritage has been conducted the longest. This has unsurprisingly resulted in the highest total number of citations, although, interestingly, not in the highest total number of papers published overall. This disparity may root in the fact that geoheritage is conducted mostly by geoscientists with a habit of publishing in journals, while cultural heritage researchers most come from the humanities and social sciences and tend to write books and other slower forms publications. The definition of a specific geological heritage field and its derivatives geoconservation and geotourism occurred much later. The first textbook on 'geodiversity', for instance, only appeared in 2009. At the same time, citation rates—both annually and annually by the author—are considerably higher in the geological branch of the heritage domain indicating a rapid development and a high publication rate.

The visualisation of the ten most productive authors per field (Fig. 1a) shows the different fields' interactions with one another. As expected, geoheritage, geoconservation and geotourism overlap but unexpectedly, dark heritage does not connect with dark tourism, which instead has a minor connection with cultural heritage. Interestingly, the fields do not directly correspond to the set relations of the most impactful papers as displayed in Fig. 1b (see supplementary information for the lists of authors, impactful papers and their publication and citation records). As regards the most impactful publications, there is a minor overlap of dark tourism and dark heritage, as well as geoheritage with geoconservation. As is evident, several authors appear multiple times with different highly cited papers and some authors feature in multiple disciplinary field lists, albeit not across the divide between the cultural and geological heritage domains. This overlap between author productivity rankings and the rankings of impactful publications hints at there being generally substantial overlap *within* the cultural and geological heritage domains, but little to no overlap *between* them.

It is noteworthy that the number of citations dramatically decreases past the first one or two top citations within most disciplinary fields. There are also differences in the publication method: while the majority of papers are published in established journals—which, however, do not necessarily have a high impact factor and many may have limited accessibility due to pay-walling—many key texts also are found within edited volumes or in monograph format. There is a general difference between the natural science and social sciences/humanities in terms of preferred publication in journal vs. book formats, in the velocity of publication and reception and in the degree to which publications are co-authored. Journal publication offers a more rapid turn-over as well as a much higher volume of an individual publication in relation to the total amount of text produced. This may at least partially explain the relatively rapid accumulation of publications and citations within the geoscience-based fields examined here.

Exploring the structure of the citation network between authors and research field underlines the lack of connectivity between geoheritage and cultural heritage (Fig. 2). As expected, geoheritage, geotourism and geoconservation are substantially interconnected and loosely connect with geoethics. Despite dark heritage being established longer, dark tourism has more published papers and citations, hence the larger circle (Fig. 2). Only M. Shackley connects dark tourism and cultural heritage (at the level of our analysis), having published one paper linking the two (Shackley 2001).

Table 1 Summary of the citation analysis exercise for cultural heritage, dark heritage, dark tourism, geoheritage, geotourism, geoconservation and geoethics. The overarching disciplinary fields of cultural and geological heritage are shaded in grey but note that the term geotourism actually appears in the literature prior to the appearance of the term geoheritage

Disciplinary field	N_{papers}	$N_{citations}$	Publication span	Citations/paper	Citations/author	Papers/author	h-index
Cultural heritage	287	28,552	1958–2016	99	18,929	195	92
Dark heritage	83	5450	1981–2017	65	3719	62	20
Dark tourism	531	13,039	1995–2018	24	9836	419	52
Geoheritage	385	2731	1993–2018	7	1591	214	23
Geoconservation	283	3957	1993–2017	13	3097	195	26
Geotourism	599	5946	1986–2018	9	3992	382	34
Geoethics	115	659	1996–2018	5	400	76	13

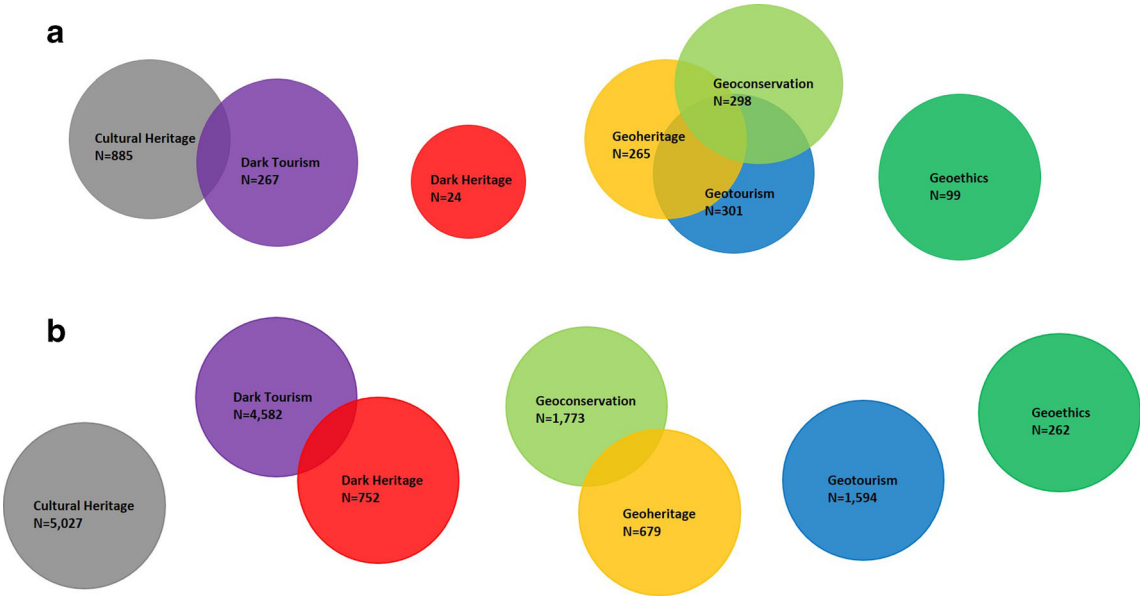

Fig. 1 **a** Visualisation of the logical set relations among the ten most prolific authors based on the number of publications that have received citations for cultural heritage, dark heritage, dark tourism, geoheritage, geoconservation, geotourism and geoethics. **b** Visualisation of the logical set relations among the ten most impactful publications based on the number of citations for cultural heritage, dark heritage, dark tourism, geoheritage, geoconservation, geotourism and geoethics

Although there appears to be little overlap between authors across the cultural and geological heritage 'divide', there is substantially more contact when considering the destination journals chosen by these authors (Table 2). The network between destination journals and disciplinary field paints a more complex picture (Fig. 3). Again, we see the proximity of geotourism, geoheritage, geoconservation and geoethics when compared with dark tourism and dark heritage. Yet, a handful of journals offer the opportunity of cross-linkage: The *Tourism Management* journal, *Journal of Heritage Studies* and the *International Journal of Heritage Studies* bridge cultural heritage, dark heritage and dark tourism, while the *Journal of Tourism Studies* and *Landscape Research* connects cultural heritage to geotourism. Interestingly, the *International Journal of Tourism Research* links cultural heritage with dark tourism, geotourism and geoethics.

It is evident that the choices made by authors active within the respective fields are rather limited (Fig. 3). Furthermore,

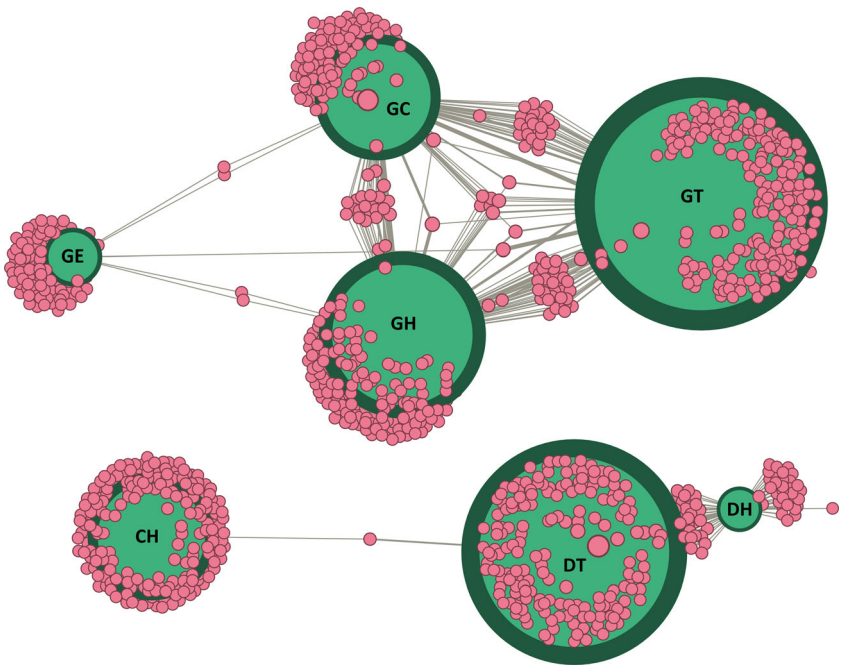

Fig. 2 Citation network of authors publishing in the seven disciplinary fields investigated. The green nodes represent the different research fields where the size of the circle represents the number of publications in the field. CH cultural heritage, DH dark heritage, GT geotourism, GH geoheritage, GC geoconservation, DT dark tourism, GE geoethics. Red nodes are individual authors' publications with citations. The way the red nodes are grouped is determined by how connected to the disciplinary field they are. The closer to the middle of the green node is, the less likely the author is to be transdisciplinary

Table 2 Summary of the ten most favoured journal destinations based on the number of papers for cultural heritage, dark heritage, dark tourism, geoheritage, geotourism, geoconservation and geoethics. A forward citation is one recent publication citing previous work; in this case, the focus was on where work was published based on the recent work citing the top 10 papers

Disciplinary field	Journal	N_{papers} with forward citations
Cultural heritage	*Journal of Cultural Heritage*	130
	International Journal of Heritage Studies	96
	International Journal of Cultural Property	61
	Museum International	51
	Journal of Heritage Tourism	26
	Conservation and Management of Archaeological Sites	21
	Journal of Cultural Heritage Management and Sustainable Development	20
	Tourism Management	16
	City, Culture and Society	7
	Annals of Tourism Research	6
Dark heritage	*International Journal of Heritage Studies*	12
	Journal of Heritage Studies	12
	Journal of Heritage Tourism	10
Dark tourism	*Annals of Tourism Research*	61
	Tourism Management	49
	Issues in Tourism	35
	Journal of Heritage Tourism	35
	Current Issues in Tourism	33
	Journal of Tourism and Cultural Change	31
	Tourist Studies	24
	International Journal of Heritage Studies	23
	International Journal of Tourism Research	21
	Tourism Recreation Research	18
Geoheritage	*Geoheritage*	307
	Acta Geologica	32
	Quaternary International	24
	Geojournal of Tourism and Geosites	21
	Sustainability	14
	International Journal of Geoheritage	5
Geoconservation	*Geoheritage*	177
	Proceedings of the Geologists' Association	55
	Quaternary International	26
Geotourism	*Geoheritage*	204
	Geotourism	167
	Geological Society	120
	Journal of Tourism	41
	Geojournal of Tourism and Geosites	31
	Acta Geoturistica	24
	Acta Geographica	22
	Quaternary International	20
	Journal of Ecotourism	15
	Tourism Management Perspectives	12
Geoethics	*Annals of Geophysics*	26
	Geological Society	18
	Engineering Geology for Society and Territory	7
	Geothics: ethical challenges (book)	6
	Episodes	6
	EGU General Assembly	6

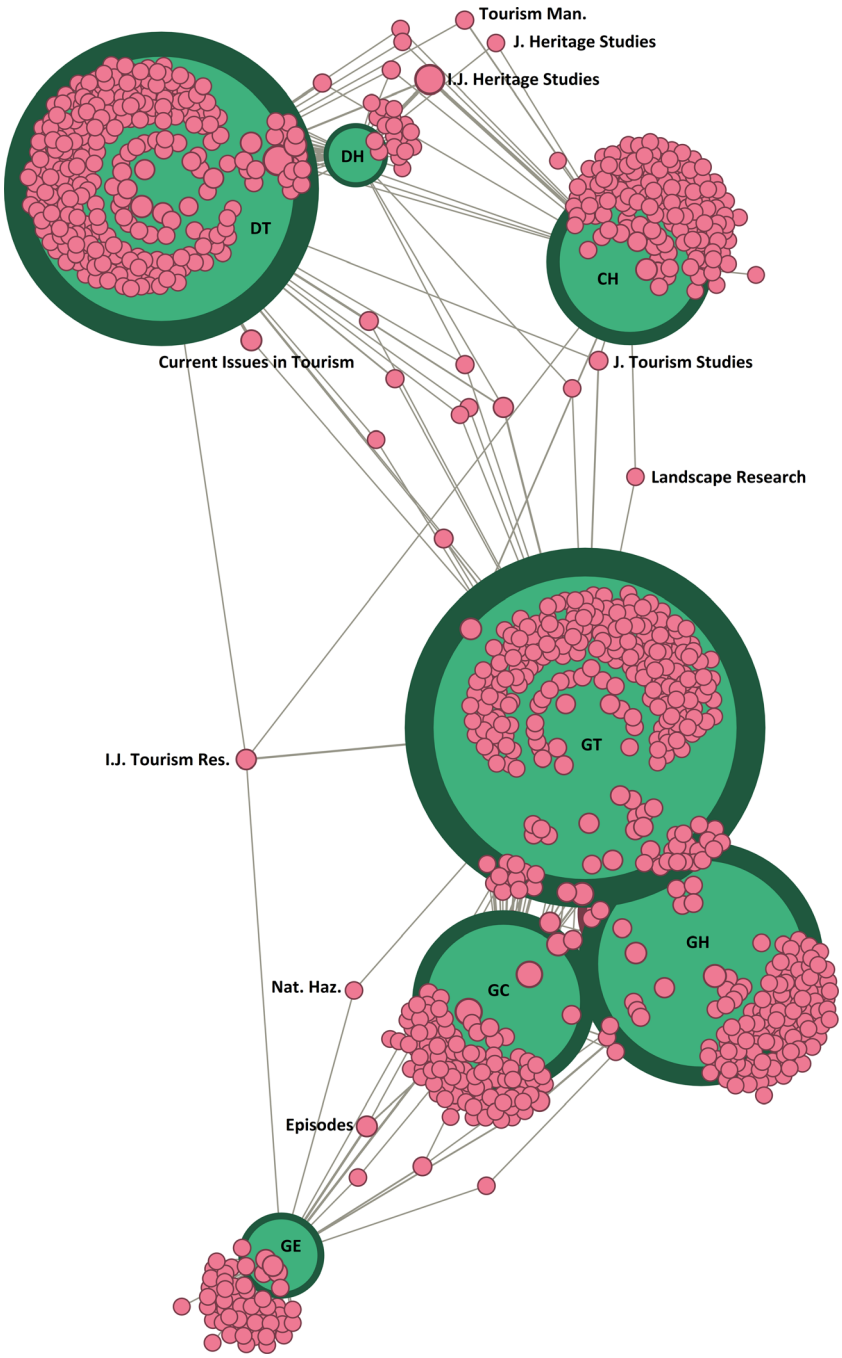

Fig. 3 Citation network of journals and the seven research fields investigated. The green nodes represent the different research fields; the size of the circles represents the frequency of publications in the field. CH cultural heritage, DH dark heritage, GT geotourism, GH geoheritage, GC geoconservation, DT dark tourism, GE geoethics. Red nodes are individual journals. The way the red nodes are grouped is determined by what kinds of journals relate to the specific research field. The closer to the middle of the green node is, the less likely the journals are to be transdisciplinary

the range of chosen journal destinations is more exclusive within some of the fields investigated: dark heritage and geoconservation research appear in only three journals respectively (*International Journal of Heritage Studies*, *Journal of Heritage Studies*, *Journal of Heritage Tourism Geoheritage*, *Proceedings of the Geologists' Association and Quaternary International*), geoheritage typically appears in five journals (*Acta Geologica*, *Quaternary International*, *Geojournal of Tourism and Geosites*, *Sustainability* and *International Journal of Geoheritage*) besides *Geoheritage*, while geoethics work appears in four journals (*Annals of Geophysics*, *Geological Society*, *Engineering Geology for Society and Territory*, *Episodes*) and as abstracts submitted to the EGU General Assembly. This trend is also evident in the forward citations: Cultural heritage destinations include venues mainly specialised in cultural heritage as well as tourism journals; dark heritage also is found within cultural heritage journals as well as in geography-related journals; dark tourism research finds its home in heritage and more general humanities journals. Both geotourism and geoheritage forward citation destinations remain broadly within the disciplinary remit of geography and geology. Geoconservation is also targeted at

geography and geology destinations, as well as ecology and conservation. One interesting and surprising finding is that each field (except for geoethics) has forward citation destinations in tourism-related journals.

Discussion

The results of our bibliometric analysis and visualisation show that the broad disciplinary fields of cultural and geological heritage are largely disconnected. A lack of citation across these disciplinary domains and their sub-fields indicates that there is little shared literature and likely little common ground in terms of terminology, theory and method. Importantly, the field of cultural heritage has the longest research and publication pedigree and cultural heritage figures prominently in the funding programs of major agencies (e.g. the EU's Horizon 2020). Furthermore, the statistics available for many countries indicate that museums of cultural history are among the major attractions for tourists and locals alike (http://www.egmus.eu/). Museums are increasingly active in relation to questions of sustainability, biodiversity and climate change (Cameron and Neilson 2015; Rees 2017), although museums of cultural history have not yet fully grasped that opportunity (Jackson et al. 2017; Jackson et al. 2018), despite the fact that the entanglement of our knowledge about past environmental change and hazards in relation to cultural history can be said to afford not only learning opportunities (Riede et al. 2016b) but also certain ethical obligations (Riede et al. 2016a). Aligning geoheritage more closely with cultural heritage would open this remarkable public interface to the concerns of geoconservation, sustainability and boost risk and natural hazard awareness—the latter of which are still rather divorced from risk, vulnerability and society. At the same time, it has been shown repeatedly that the humanities and social sciences remain side-lined in major efforts such as the Intergovernmental Panel on Climate Change's (IPCC) reports (Hulme 2011; Corbera et al. 2016) and in the distribution of funding within disaster risk reduction research (Alexander 1997). A closer alliance between cultural and geological heritage practitioners could thus not only increase public but also policy-maker impact. UNESCO's International Geoscience Programme (IGCP) in principle presents a strong high-level platform for such engagement. Two recently launched projects aim to address the salient linkage between cultural heritage, geoheritage and risk reduction (see https://en.unesco.org/news/eight-new-projects-societal-relevance-join-international-geoscience-programme).

Mindful of these results and in an effort to support our argument that investigations of volcanic geoheritage—and geoheritage in general—can draw benefits from joint attention from both perspectives, we now briefly illustrate how such a geocultural heritage perspective could take form. We focus on four volcanic eruption/landforms (Soufrière Hills Volcano, La Soufrière, Vesuvius and the Laacher See) in order to show how both active and dormant volcanoes and their different cultural and geological heritage components can be brought into play. In this effort, we focus specifically on aspects of dark heritage, i.e. aspects of these geosites that place themselves in the "tense intermediary zone between voyeurism and social justice" (Robb 2009, 58) and how this dark heritage can be combined with issues of risk reduction.

Soufrière Hills Volcano, Montserrat

Soufrière Hills Volcano, on the Lesser Antilles island of Montserrat, has been periodically erupting since 1995 (Sword-Daniels et al. 2014), and with geological evidence that similar activity occurred just before first European settlements in 1632 (Smith et al. 2007). The island's name Montserrat was coined by Christopher Columbus on his second voyage; its earlier name was Alliouagana, and archaeological evidence indicates settlement by the indigenous Amerindian Saladoid from 500 BCE to 545 CE groups (Reid 2009) and the Arawak settled the Lesser Antilles from approximately 3000 BCE (Cherry et al. 2012). In the Lesser Antilles, the Arawak were then displaced by the Kalinago from approximately 1200 CE (Lalubie 2013). It is uncertain of what became of the Kalinago when the first colonial settlers from Virginia and St. Kitts arrived. There is also a complex relationship here with the almost continuous aggression between the French and the English at this time and relations with the colonies in the USA (Fergus 1981). However, after the English seized Montserrat in 1667, Irish indentured servants and African slaves were imported, displacing Irish smallholders replacing them with larger plantation operations (Russell 2015). The most curious cultural heritage aspect of the island may be St. Patrick's Day, which is embraced by the Irish-African creole society. While it was originally celebrated by the Irish, a failed slave revolt took place on March 17, 1768 (Fergus 1996) and for future generations captivated the imaginations of the creole society to the point that the failed rebellion was incorporated into the popular festivities (see https://www.irishcentral.com/roots/montserrat-irish-st-patricks-day). The festival's meaning has changed throughout the island's colonial history reflecting, variously and in contested ways, strong postcolonial tendencies, left-wing politics, the Black Power movement and the role of the Roman Catholic church. In addition, the Soufrière Hills eruption of 1995 irrevocably altered the spatial expression of the festival's home making it a focal point of the disaster diaspora (McAtackney et al. 2014).

The volcanic island's most prominent development issue has been the abandonment, following the 1995 eruption, of over 50 settlements in the south of the island, where a permanent exclusion zone of Soufrière Hills Volcano is in effect (Fig. 4). Consequently, development is currently restricted to the north of the island, where new settlements are slowly

being developed. Two developments recently focus on a tourism policy with the explicit creation of museums and monuments associated with eco- and geotourism, with funds released by the European Union (https://discovermni.com/2018/02/23/montserrat-signs-edf-11-for-18-4m-euros-at-octa-conference/). Furthermore, as of 2017, tour guides have been training for accompanied tours into the exclusion zone to the outskirts of Plymouth (Skinner 2018). The inhabitants of Montserrat are on their way to exploiting its dark tourism related to past human impacts and contemporary risks. The Soufrière Hills eruptions are well-investigated volcanologically, and the remains from its most recent eruptions offer touristic and research opportunities today. Yet, they also reflect a more troublesome legacy of colonial rule (e.g. Charvériat 2000; Spence et al. 2007; Kelman and Mather 2008; Donovan et al. 2014; Barclay et al. 2015).

Indeed, the recent history of the island epitomises issues of colonial rule and how contemporary world systems fell into place. It is a history of marginalised groups (e.g. Mlambo 2006; McGrattan 2010; Montero 2011; Boyle 2011) and a history that can be linked to issues of social justice (Wolf 1990) and of contemporary environmental concerns (Lewis and Maslin 2015). The destruction of the capital Plymouth is akin to the destruction of St. Pierre, Martinique by Mont Pelée in 1902 (Fig. 5), which had far-reaching effects in terms of early disaster medialisation (Kverndokk 2015). St. Pierre has been nicknamed the "Pompeii of the Caribbean" (Janssens and O'Keefe 2010), and Plymouth, too, has been described as a "modern-day Pompeii in the Caribbean" (Bachelor 2014). But the cliché of Pompeii is itself contested and a decidedly Eurocentric short-hand for a moment frozen in time (Holmberg 2013). Both Caribbean capitals are dark heritage sites, both because of the obvious destruction wrought by the respective eruptions but also because of the colonial and racial narratives they offer. Visiting these deserted places is very much dark tourism for those from the outside, while the land is being reclaimed in an ad hoc fashion by those who in fact live there (Skinner 2018). Both places carry an inheritance of loss, to use Holmberg's (2013) term. With due tact, respect and professional diligence, this inheritance—this geocultural heritage—could be turned into powerful generators of substantive insight and sustainable income. Here, the community archaeology approach—a branch of archaeology concerned with inclusion, participation, education and interaction rather than a one-way conferral of knowledge—could leverage cultural heritage to focus also on the intimately related topics of social justice and vulnerability (Ryzewski and Cherry 2012; Cherry and Ryzewski 2014).

La Soufrière, St. Vincent and the Grenadines

La Soufrière Volcano, on the main island of St. Vincent, is one of the most active volcanoes in the Lesser Antilles Volcanic Arc (Robertson 1995), last erupting explosively in 1979 and with effusive lava dome growth until 1984 (Robertson 2005). The small island state shares much history and many contemporary challenges with Montserrat and other islands in the region (Briguglio 1995). Currently, research draws on the past two eruptions of 1979 and 1902–1903 to prepare for the future and for capacity building—through an annual volcano awareness week that coincides with the 1979 eruption commemoration where school children and the wider public are educated about the volcano in a semi-formal setting (Fig. 6).

Fig. 4 Aerial photograph of Plymouth and the surrounding area buried by pyroclastic density current and lahar deposits by Lally Brown, June 1997

Fig. 5 **a** Abandoned Plymouth by Lally Brown, 1996. **b** The rebuilt Statue of Mary in St. Pierre, Martinique, by D. Morvan, 2006

Besides the physical presence of the active volcano and extinct volcanic centres forming a central axial range of mountains (Robertson 2005), various outcrops exist that offer outstanding examples of volcanic island processes. Various popular eco-tourism routes criss-cross the mountain range, rainforests and bays (SVG Tourism Authority 2009) (Fig. 7), and Amerindian petroglyphs are present across the island, which are likewise a source of tourism income that have been submitted for consideration as cultural heritage sites (UNESCO 2018) (Fig. 7). It would not only be possible to integrate these routes with a narrative of the geology of the island but to integrate community-led research into the exploration of these prehistoric landscape features, for instance under the auspices of the UNESCO network 'Geoheritage for resilience'.

St. Vincent and the Grenadines have a complex colonial history, which has contributed to both ethnic and religious diversity in the present (e.g. Brathwaite 1971; Bolland 1998; Shepherd and Richards 2002; Finneran 2013). This history has not been a happy one and encapsulates many aspects of the emergence of contemporary world systems as well as the emergence of our contemporary environmental quandaries (Lewis and Maslin 2015). Yet, the history of slavery and colonialism has been embraced and exploited as a form of dark heritage on other Caribbean islands, in the southern USA and in West Africa (e.g. Dann and Seaton 2001; Mowatt and Chancellor 2011; Tunbridge and Ashworth 2017). Weaving narratives of volcanic unrest and human impact together with narratives of colonialism, resistance, migration, social and environmental justice may yet be for the benefit—also in terms of tourism-generated income—for all involved.

Fig. 6 School children learning about volcanoes and La Soufrière during the 2016 Volcano Awareness Week (by Jazmin Scarlett, April 2016)

Vesuvius, Italy

The cities of Pompeii and Herculaneum are known the world over and are, in fact, prime examples of dark heritage. Their discovery was integral to the development of research fields such as archaeology, just as research on Vesuvius has been integral in the development of volcanology—so much so that the very term Pompeii has become a common and more often than not misleading idiom for some site—tephra-covered or not—frozen in time (cf. Holmberg 2013). Pompeii does offer unprecedented insights into the life of the Romans (Beard 2008) and has long inspired art, theatre and film (Beard 2008; Pomeroy 2008; Sigurdsson 2015). The volcano looming over the city of Naples and the world famous casts of agonisingly dying animal and human inhabitants of this ancient city adds its element of titillation (Kulcsar and Simon 2015), together making Pompeii a tremendously attractive site for visitors (Fig. 8). In 2014, nearly 2.5 million

Fig. 7 **a** The La Soufrière Nature Trail by Jazmin Scarlett, April 2016. **b** A petroglyph of St. Vincent and the Grenadines by Megan Walker, 2017

visitors came to Pompeii (Italian Ministry of Culture 2014). In 2017, this number rose to over 3.4 million and many more see the various exhibitions staged about Pompeii in museums around the world (e.g. at the British Museum in 2013, see http://www.britishmuseum.org/whats_on/exhibitions/pompeii_and_herculaneum.aspx). In 2004, about one million visitors came to the Vesuvius National Park (Erfurt-Cooper 2010a). Unfortunately, no information could be found to provide up-to-date statistics to provide a sufficient comparison.

Effective outreach about risk and vulnerability, coupled with geocultural heritage is already going on at Pompeii (see https://www.parconazionaledelvesuvio.it/en/ and http://www.ov.ingv.it/ov/en.html). These include 'Wine Tours' (https://www.veltra.com/en/europe/italy/napoli/a/128400), that for wine tasters, combine the educational value of visiting the archaeological ruins and Vesuvius, while sampling wine grown on the slopes of the volcano. Neapolitan researchers and authorities are doing their best to make full use of the remarkable coupled heritage at their disposal. It is not, however, strongly visible in the literature and rarely framed as such. Given, however, just how many people—locals and tourists alike—are at risk from renewed eruption at Vesuvius (Zuccaro et al. 2008; Scandone et al. 2015), effective risk communication is a high priority. There is great awareness of this need and ethical obligation to communicate these risks (Solana et al. 2008; De Lucia 2014). Including elements of cultural framings of risk and response (Everson 2012; Chester et al. 2015) may assist in these endeavours.

Laacher See, Germany

The eruption of the Laacher See volcano, part of the Eifel volcanic zone located in present-day Germany, around

Fig. 8 **a** A classic image of Vesuvius that forefronts the cultural heritage in the form of Pompeii, deliberately chosen from Wikipedia (Morn the Gorn - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=7919520). **b** A film poster of one of the many productions of the *Last Days of Pompeii*, going back to the painting of the same title by Karl Bryullov from 1833

Fig. 9 A drone photo of the Laacher See caldera by Florian Sauer, May 2018

12,900 years ago was the last major volcanic event in continental Europe. Lasting up to several months, it devastated the immediate surroundings (Schmincke et al. 1999; Schmincke 2006). Its eruption sequence and associated processes such as the formation and subsequent collapse of a dam on the nearby river Rhine are well investigated (Park and Schmincke 2009). Indeed, recent research motivated by a concern about the eruptions impact on human communities at the time has highlighted the extent of the tephra fallout from the eruption (Riede et al. 2011) and the likely impacts of this eruption on animals, plants and people living in Europe at the time (Riede 2008; Riede 2016; Riede 2017a, b). The Eifel is a recognised UNESCO Geopark (see https://www.geopark-vulkaneifel.de/en/); the Laacher See is a beautiful recreational area (Fig. 9) and much vigorous outreach focusing on the region's rich geocultural heritage—Roman and Medieval mining, underground beer storage and contemporary industry (Custodis 1994; Kremer 1995)—is going on (Erfurt-Cooper 2010b).

We note, however, that much of this outreach circumvents issues of past human impacts (Bitschene and Schüller 2011; Bitschene 2015) and hence underutilises the opportunity of putting issues of vulnerability and resilience to debate and underutilises the touristic appeal of the eruption's dark heritage. While unlikely in the near future, any potential reawakening of this volcano would likely result in major infrastructure costs (Leder et al. 2017) or even secondary technological disasters with not merely local effects but reverberations across Europe (Fig. 10). Many major European population centres as well as important infrastructure elements—including nuclear power plants and several major airports—are located in the vicinity of the Laacher See. The issue of the lasting legacies of nuclear waste, in particular, has been dealt with by cultural heritage professionals (Holtorf and Högberg 2014), and bringing extreme geological events over longer timescales into play makes such questions all the more acute. Moreover, and perhaps more usefully still, the Laacher See can be used as a case study for seriously thinking through the societal consequences and responses to events of this magnitude and to do so in a manner that is historically informed by what we know of past impacts (Donovan and Oppenheimer

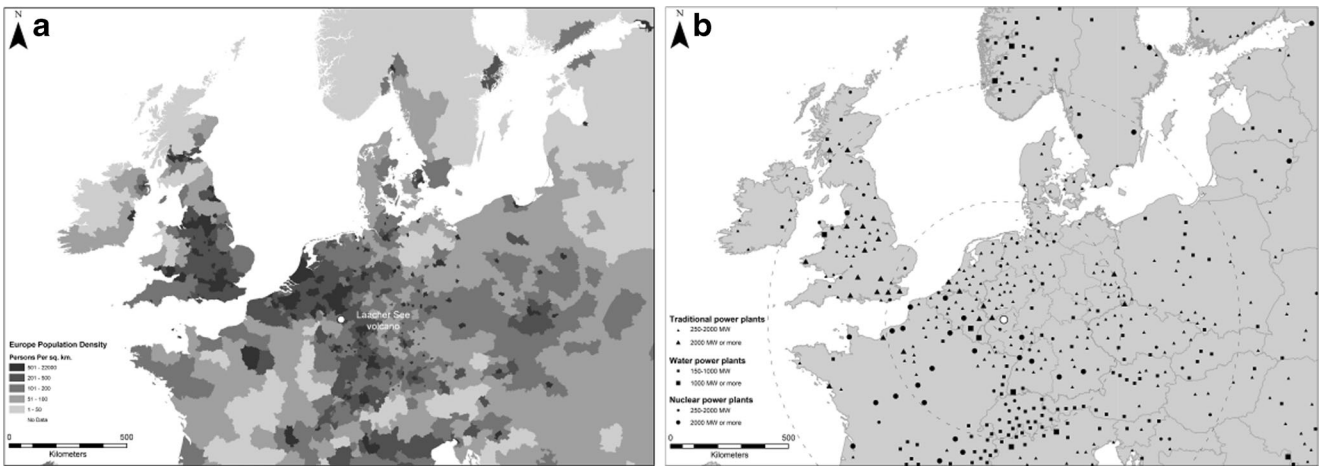

Fig. 10 The location of the Laacher See and proximal (< 50 km), medial (50–500 km) and distal (500–1000 km) hazard zones, following Thorarinsson (1979), in relationship to **a** European population density and **b** major power plants

2016; Riede 2017a). In this context, scenarios of future eruptions can be used to ask critical questions about the dark heritage of capitalism, international aeromobile tourism and the legacy of industrialisation (Brewer and Riede 2018). Strategic and balanced inclusion of the Laacher See's dark heritage would likely further increase the region's and the eruption event's appeal and hence lift the reach of any associated educational initiatives up on a supra-regional scale.

Conclusion

Volcanoes and their landforms are natural features and are also commonly deeply entangled with human history, culture and society. Culture history and cultural heritage are a resource on which people anywhere draw for identity formation and for social capital for sustainability and well-being (Hølleland et al. 2017). Assessments of risk in general and of volcanic risk, vulnerability, resilience and their translations into hazard maps and warning messages all require cultural understanding. Cultural values and perceptions provide saliency to specific hazards through specific and culturally variable prioritisation of threats (Cutter et al. 2008).

Historical data—geological, archival and archaeological—of past eruptions can be fed into building community resilience through education and knowledge systems, participatory research, a deep sense of place, tourism, spirituality and religion, social relations, aesthetic values and recreation. Accepting the entanglement of geological and cultural heritage, we have here deployed the notion of geocultural heritage and have presented some initial suggestions for how certain aspects of cultural heritage can usefully be blended with aspects of geological heritage. Seen against the background of our citation analysis, we argue for increased interdisciplinarity. Cultural heritage professionals have developed countless ways of engaging local communities in the context of, for instance, community archaeology projects (Moshenska and Dhanjal 2011; Moshenska et al. 2011; Fernández et al. 2017). Cultural heritage sites almost universally tell stories of past human-environment relations (Rockman 2015; Hambrecht and Rockman 2017) and from here it is but a small step to thinking volcanic hazards together with cultural heritage and cultural history—a trend that is in fact already on-going (Cronin and Cashman 2007; Cashman and Cronin 2008; Cashman and Giordano 2008; Németh and Cronin 2009). Our citation analysis may not adequately reflect the full range of current practices—much geocultural work might not get published—but we hope that it draws attention to a wider palette of relevant intellectual, methodological and practical resources.

Millions of visitors are attracted by the wonders of volcanoes and volcanic landforms every year (Erfurt-Cooper and Cooper 2010; Erfurt-Cooper et al. 2015; Jones and Ohsawa 2016; Németh et al. 2017). Their popular appeal is substantial. Yet, we have argued here, this appeal can be enhanced further through a strategic alliance between geoheritage and cultural heritage researchers and managers. Several points stand out clearly. First, attractions tend to command greater attention and hence generate more income, jobs and attention when marketed *primarily* as cultural heritage attractions. Cultural heritage professionals have developed, over the many years since the establishment of this field of research, numerous approaches to understanding and managing such sites and their attendant issues. Second, heritage is often contested and robust handling of any heritage feature—geological or otherwise—must be attuned to the potential of diverging viewpoints and value assignments. This is also at the core of dark heritage, where problematic or uncomfortable sites actually generate great visitor appeal and hence present themselves as particularly powerful places of engagement. Here, we have merely touched upon how issues of colonialism, slavery, non-renewable resources, vulnerability and resilience can be woven into the narratives about particular eruptions. More broadly, a greater cultural and political awareness in geoheritage also relates to issues of diversity and inclusiveness.

Breaking down the increasingly artificial boundaries between natural/geological and cultural/historical heritage can be achieved through wider reading and publication—we have provided go-to lists of the most important authors, articles and journals—and more interdisciplinary collaboration across the domains of geological and cultural heritage. Future research could profitably extend our analytical approach to other languages, e.g. Chinese and Spanish, and include a wider range of search terms (e.g. geoparks). Resulting outreach efforts can be brought into effect through, for instance, museums or local interest groups that provide uniquely suitable platforms for such engagements. Such interdisciplinarity would, we argue, be to the mutual benefit of both domains.

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